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AIR BLAST PARAMETERS AND OTHER CHARACTERISTICS OF NITROGUANIDINE AND GUANIDINE NITRATE

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IIT Research Institute

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SHEPHERD LEVMORE

NOVEMBER 1975

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Blast measurements were made of nitroguanidine (NGu) and guanidine nitrate (GuN) under scaled-down conditions simulating the mass of material and confinement found in storage bins used in processing plants. The results for pressure and impulse are presented in tables and graphs. Maximum TNT equivalencies for pressure and impulse at scaled distances varying from 3 to 40 ft/lb$^{1/3}$ are given. Information concerning the shock and explosive characteristics of NGu and GuN is provided.

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The important influence of density on establishing the critical diameter of unconfined NGu powder is shown.

The effect of top vs bottom boostering is given for each material.

The citation in this report of the names of commercial firms or commercially available products or services does not constitute official endorsement or approval of such commercial firms, products, or services by the US Government.

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FOREWORD

The U. S. Army Materiel Command has initiated a program to improve safety standards in ammunition plants. To accomplish this goal, design and safety engineers need to know the maximum blast wave capability of the explosive and deflagratable materials used in the production of ammunition.

Since the air blast characteristics of two little known explosive materials, nitroguanidine (NGu) and guanidine nitrate (GuN), are not covered in available literature, Picatinny Arsenal was assigned the responsibility of establishing TNT equivalencies for these two materials. The actual testing involved was accomplished by the IIT Research Institute, Chicago, Illinois, under Contract DAAA21-72-C-0695.

The results of this study should be of particular interest to designers of new facilities which will process NGu and GuN. Because of the dearth of available data (GuN, for example, is not mentioned in AMCP 706-177, the Engineering Design Handbook--Explosives Series), this report covers sensitivity, thermal qualities, and other explosive characteristics in addition to the required TNT equivalencies. By presenting all of this information in one publication, the author hopes this report will be a meaningful contribution to the literature, and a useful source of information.

This report has been approved for issuance by AMSAR-SFD and AMCSF-E (see Appendix).

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SUMMARY

This report provides the reader with background information pertinent to the shock sensitivity and basic explosive characteristics of nitroguanidine (NGu) and guanidine nitrate (GuN). It shows that the critical diameter of unconfined NGu lies above 1.27 cm at any density, but at a density of 1.5 g/cc, a diameter of 1.43 cm will suffice. Also shown is the fact that at lower densities and larger diameters this material can enter a pseudo-detonation regime in which the propagation velocity can range from 3 to 5.7 mm/μsec in lieu of the normal detonation rate of 7 or more mm/μsec.

Since the NGu used in the blast output (TNT equivalency) tests described in this report was unconfined and not pressed, it is assumed that it propagated at a lower than maximum rate, possibly below the rate of detonation. The minimum rate of detonation is the velocity of sound through the material; anything less should properly be referred to as deflagration.

GuN is portrayed as an insensitive material with limited explosive strength and a low detonation rate. Due to this low propagation rate, it is doubtful that a true detonation was obtained in the blast tests described in this report.

Eight tests were conducted with nitroguanidine charges in simulated aluminum storage bins. Since the charge-weight to metal-weight ratio of these bins was scaled, the degree of confinement of the test charges, like the full scale system, is insignificant but similar. The charges varied in weight from 6 to 110 pounds and were initiated from the bottom. In all cases, the test sample detonated. The scaled magnitude of the blast outputs was similar in spite of variations in booster and charge weights. Measured pressures ranged from 140 to 1 psig at scaled distances of 3 to 37 ft/lb$^{1/3}$, respectively. Scaled positive impulses ranged from 28 to 1.7 psi-msec/lb$^{1/3}$. The maximum pressure and impulse TNT equivalencies are 140 to 110 percent, respectively, at a scaled distance of 3 ft/lb$^{1/3}$.

Four tests were conducted with lightly confined GuN charges weighing 240 to 800 pounds. The GuN was initiated with a Composition (Comp) C4 explosive booster embedded in the top of each charge. Free field pressure and impulse measurements were made in the scaled distance range of approximately 2 to 50 ft/lb$^{1/3}$. The pressure and impulse values were compared to those produced by a hemispherical surface burst of TNT in order to determine the TNT equivalency. The peak pressure TNT equivalency ranged from

140 to 16 percent at scaled distances of 3 to 40 ft/lb$^{1/3}$. The GuN tests showed that the scaled airblast parameters and TNT equivalency results for the charges tested showed no significant differences due to either the weight of the charge or the size of the booster.

INTRODUCTION

Methods used in the past for siting and designing components of explosives and propellant manufacturing plants and related facilities have been based on gross quantities of detonatable materials. Present day technology has shown that cost effective yet safe facilities can be built if design criteria are based on the actual explosive output of the materials involved.

TNT Equivalency Testing

A considerable amount of work has already been performed in establishing the air blast parameters of TNT. Consequently, for facility designs involving other energetic materials, the required design information can be expressed in terms of "TNT equivalency."

TNT peak pressure and impulse equivalencies are obtained by determining the weight of TNT that would produce the same peak pressure or impulse, at the same distance, as any given test charge. It is the ratio of this weight of TNT to the test charge weight (wt TNT/wt test charge) that defines TNT equivalency. For example, if the TNT pressure equivalency of the test charge is 10 percent, then one pound of TNT would give the same overpressure at the same distance as 10 pounds of the test charge. The comparisons (reference curves) are based on an unconfined hemispherical surface burst of TNT, even though the test charges were a different configuration.

Scaling

A detonation is a virtually instantaneous chemical reaction that liberates large quantities of gases and heat. The gases are under extremely high pressure (up to 2,000,000 lb/in.^{2} off the face of a charge) and consequently expand rapidly, as shown in Figure 1 (c, P_s), pushing the atmospheric air away so fast that it causes a shock wave. The pressures created by a shock wave endure for a period of time [Δ t]. They can destroy buildings and register their passing strength on gages.

Scaling means that the pressures, impulses, duration, and arrival time from a given explosive charge are predictable for charges of other weights provided that all other conditions (density, geometry, confinement, etc.), are constant. The scaling equation is $Z = (R/W^{1/3})$ Po. Z is the scaled distance in ft/lb$^{1/3}$; R is the radial distance from the center of the charge in feet; W is the weight of the charge in pounds and Po is the ambient pressure in atmospheres. The relationship is illustrated in Figure 1 (a). If blast measuring devices were placed at various distances from a

10-lb charge, then the recorded peak overpressure would be represented by curve W1. Curve W2 would be developed if a 100-lb charge were detonated at the same point. In this way, a family of parallel curves is obtained for various explosive weights. By dividing actual gage distances by the cube root of the charge weight, a single curve evolves when scaling is applied. See Fig 1 (b). This curve enables an estimated calculation of peak overpressures for any specified charge weight and distance.

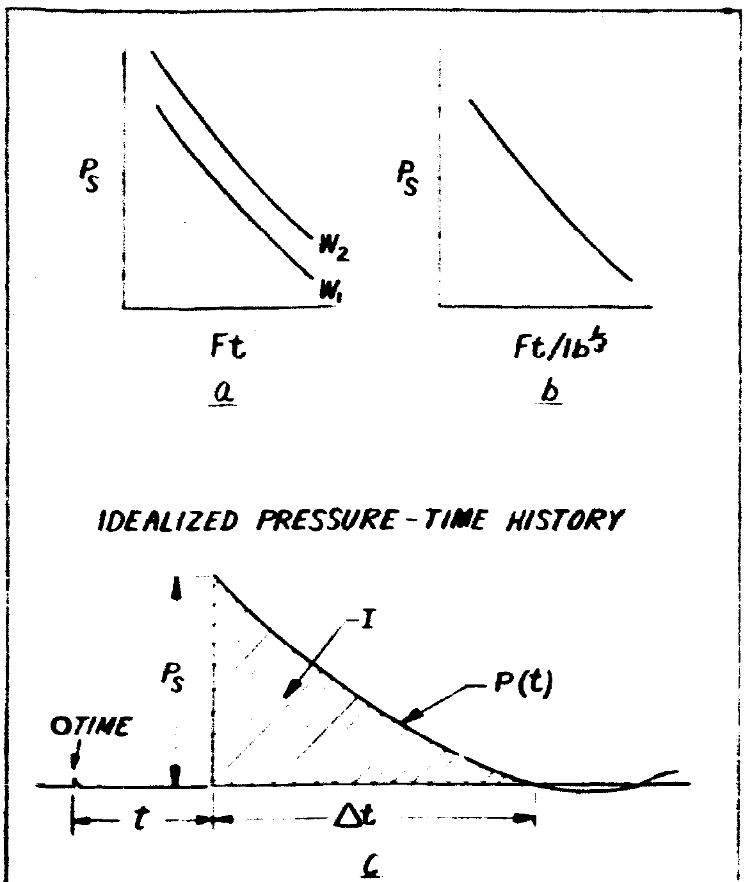

Fig 1 Scaling

In this report, scaled distances and scaled impulses have been corrected to account for the energy contribution of the booster. The explosive weights are based on total charge weights; therefore, they can be used directly when computing TNT equivalency. The mean curves were obtained by mathematically fitting the data points. A method developed by the IIT Research Institute was used to calculate the TNT equivalency of the booster. (See Appendix B to Reference 1.)

Objectives

The investigation covered in this report was undertaken:

1. to determine the maximum pressure and positive impulse of NGu and GuN in terms of TNT equivalencies, and

2. To ascertain the applicability of the air blast scaling law to these explosives.

DISCUSSION

Shock Sensitivity

NGu is less sensitive to certain types of shock stimuli than most standard explosives such as TNT. Table 1 summarizes the available sensitivity data (in comparison with TNT) and shows that GuN is even less sensitive than NGu.

TABLE 1

Sensitivity characteristics of NGu and GuN

Explosive	Impact (kg and in.)	Bullet (.30 cal)	Initiation (lead azide)	Friction	Vacuum Stability (120°C)
NGu	2/26	NR	0.20	NR	0.44
GuN	10/43	NR	INC 2 lb Comp C4		----
TNT	2/14-15	Expl, 40%	0.27	NR	0.23

NR = No reaction
INC = Incomplete reaction

A booster initiation test indicated that GuN is significantly less sensitive to shock than NGu. In this test six lightly confined, loosely packed charges of NGu were initiated by a 1.06-oz tetryl booster placed at the bottom of each charge (Fig 2). However, under similar conditions, GuN responded with an incomplete reaction even though the booster size was increased by increments to 16 oz of Composition C-4 (RDX/plasticizer 91/9) (Ref 1).

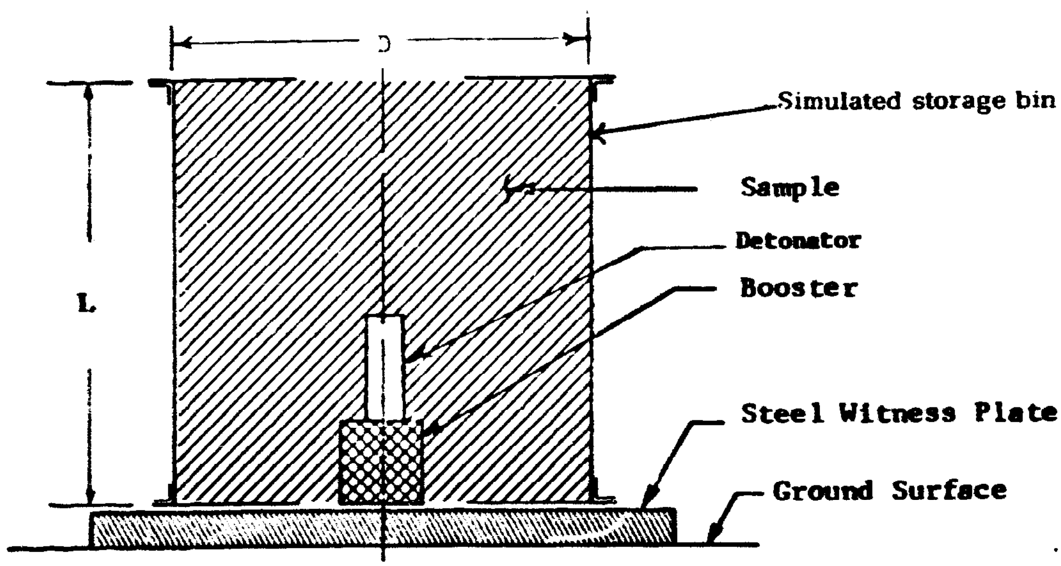

Fig 2 Loosely packed NGu in test configuration

Explosive Characteristics

GuN is considered a very weak explosive showing a Trauzl test value of only 10 percent that of TNT and a detonation velocity of 3700 m/s. NGu was rated at 95 percent of TNT in a plate dent test, but in the brisance test it rated only 73.5 percent (Ref 2). Table 2 summarizes the available explosive data in comparison to that of TNT.

Table 2

Explosive output of NGu and GuN

Material	Trauzl (%)	Detonation[a] (velocity)	Density (g/cc)	Ballistic Mortar	Brisance (%)
NGu	101	[c]7650	at 1.5	104	95
GuN	10	[c]3700	at 1.0	--	--
TNT	100	6640	at 1.56	100	100

c = confined in steel tube

Detonation Rate

The detonation rate of unconfined NGu can vary from 2.966 to 8.106 mm/μsec, varying largely with density, but diameter is also a factor. The high velocity was obtained at a diameter of 3.653 cm and a density of 1.627, which is rather difficult to attain. At the same diameter, lower densities will generate lower velocities (Ref 3). Since all of the blast tests reported in this study were conducted at very low densities (the only compaction being the weight of the dry powder), the detonation rates are assumed to be low.

Critical Diameter

A 70 mm smear camera at a writing speed of 1 to 3 mm/μsec was used to approximate the critical diameter of NGu (Ref 3). Critical diameter is the minimum diameter at which an explosive can maintain a full and constant rate of detonation under a given set of conditions.

An analysis of selected shots from the investigation reveals the following (Table 3):

1. Shots 105, 106, and 107, the largest diameter charges, gave what may be considered a full detonation, with velocity over 7000 m/s.

2. Shots 102 and 103 showed that when the diameter remains constant, but the density of the charge is reduced, the velocity falls to a pseudo-detonation, under 5000 m/s.

3. Shot 159, though of a smaller diameter, had a full detonation rate because the density was high.

4. Shot 162 exhibited full detonation at a high density.

5. Shot 215, however, with the same diameter as shot 162, had an incomplete detonation due to lower density. At this density, it is below the critical diameter.

6. Shot 163 proved that it is below the critical diameter because it failed to complete its propagation, even though an extra booster was added to a high density charge.

Analysis of these shots shows that the critical diameter of unconfined NGu is above 1.27 cm and varies with the density. See Figure 3.

TABLE 3

Detonation velocities of unconfined NGu[a]

Shot no.	Diameter (cm)	L/D (ratio)	Density (grams/cc)	Detonation velocity (mm/μsec)	Fade-out distance[b] (diameter)
105, 106 &107	3.810	5.3	1.389	7.129 avg	C
102 & 103	3.810	5.3	0.902	4.772 avg	C
159	1.588	12.8	1.517	7.452	C
162	1.429	14.2	1.524	7.403	C
215	1.429	14.2	1.216	4.510	4.5
163	1.270	16.0	1.521	7.05	13.0 EB

[a]Data obtained from U. S. Naval Ordnance Laboratory (Ref 3, Table 3)

[b]C = Complete detonation for charge length of 20.32 cm

EB = Extra booster

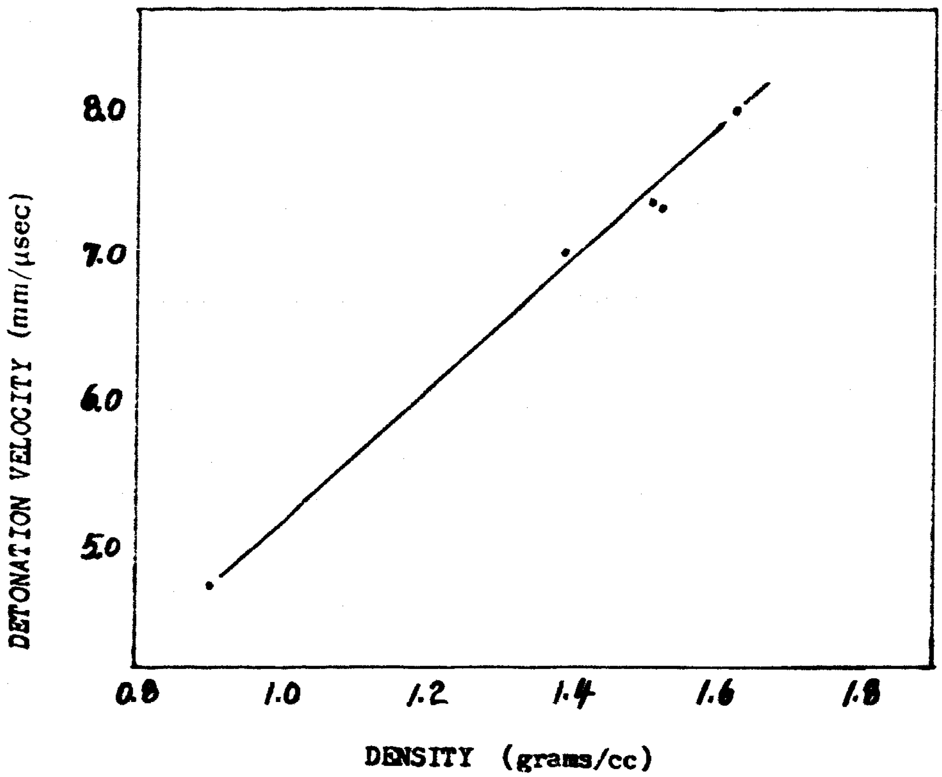

Fig 3 Relationship of detonation velocity to density for NGu

Thermal Parameters

The thermal properties of both NGu and GuN in comparison with TNT are given in Table 4.

TABLE 4

Thermal parameters of NGu and GuN

Material	Explosion temperature (5 sec)	Heat of combustion (cal/gr)	Heat of explosion (cal/gr)	Heat of formation (cal/gr)
NGu	275^{o} C	1995	721	227
GuN	-	1715	610	754
TNT	475^{o} C	3620	1080	78.5

EXPERIMENTAL TEST RESULTS

Nitroguanidine

Background

In 1901 Vielle, the famous French explosives expert, investigated the possibility of using NGu as a temperature reducing agent. He found that when a 10 to 15 percent quantity of NGu was added to nitrocellulose, the resulting propellant was practically flashless and less erosive than other propellants of comparable force. However, due to the presence of sulphur, this propellant was not stable in storage.

Cool, flashless, sulphurless and non-erosive propellants containing NGu and DEGN were developed in Germany prior to and during World War II, under the direction of General Gallwitz. In Germany, propellants containing NGu are called "gudol pulver" (Ref 2), whereas in England they are called "picrite" even though they do not contain any picric acid.

An independent evaluation of NGu- vs non-NGu-bearing propellants was made in this country. It shows that at equal temperatures, NGu-bearing propellants cause less weight loss and erosion of gun tubes than non-NGu bearing propellants (Ref 4).

Test Results

The test factors used in the current series of tests are outlined in Table 5; the physical set-up is illustrated in Figure 2. The NGu detonated in every test, leaving no unburned residue. The witness plates were bent and/or cracked, and the aluminum cylinders were shattered into very small fragments.

The results of blast measurements for peak pressure and scaled impulse were plotted versus scaled distance. Figures 4 and 5 illustrate the effects of two booster sizes, 1.06-oz tetryl vs 4-oz Comp C4, on two different charge weights, 50 and 100 pounds of NGu. Virtually no additional blast output was obtained when the larger booster was used. The differences in peak pressures shown are within the realm of experimental error.

The effects that four different NGu charges weighing 5.86, 24, 50, and 110 pounds have on pressure and impulse are shown in Figure 6 (for tetryl boosters) and Figure 7 (for Comp C4 boosters). These weights represent scale factors of 1/8, 1/5, ≈ 1/4, and 1/3. Differences in peak pressure and impulse are insignificant for sizes evaluated. It

Table 5

NGu test factors

Test no.	Booster size	Charge weight[a] (lb)	Scale Factor	L=D (in.)[b]	Hole size (in.)	Aluminum thickness (in.)
NGu 1	30 gm tetryl	5.86	1/8	9-1/2	3-3/4	0.012
NGu 2	30 gm tetryl	24.0	1/5	15-1/4		0.020
NGu 3	30 gm tetryl	110.0	1/3	26-1/4	5-1/2	0.032
NGu 4	4 oz Comp C4	110.0	1/3	26-1/4		0.032
NGu 5	30 gm tetryl	5.86	1/8	19-1/2	6-3/4	0.025
NGu 6	30 gm tetryl	24.0	1/5	15-1/4		0.020
NGu 7	30 gm tetryl	50.0	1/4	19-1/2	9-1/4	0.025
NGu 8	4 oz Comp C4	50.0	1/4	19-1/2		0.025

[a]Density, approximately 0.24 gram/cc.

[b]Length-to-diameter ratio is one.

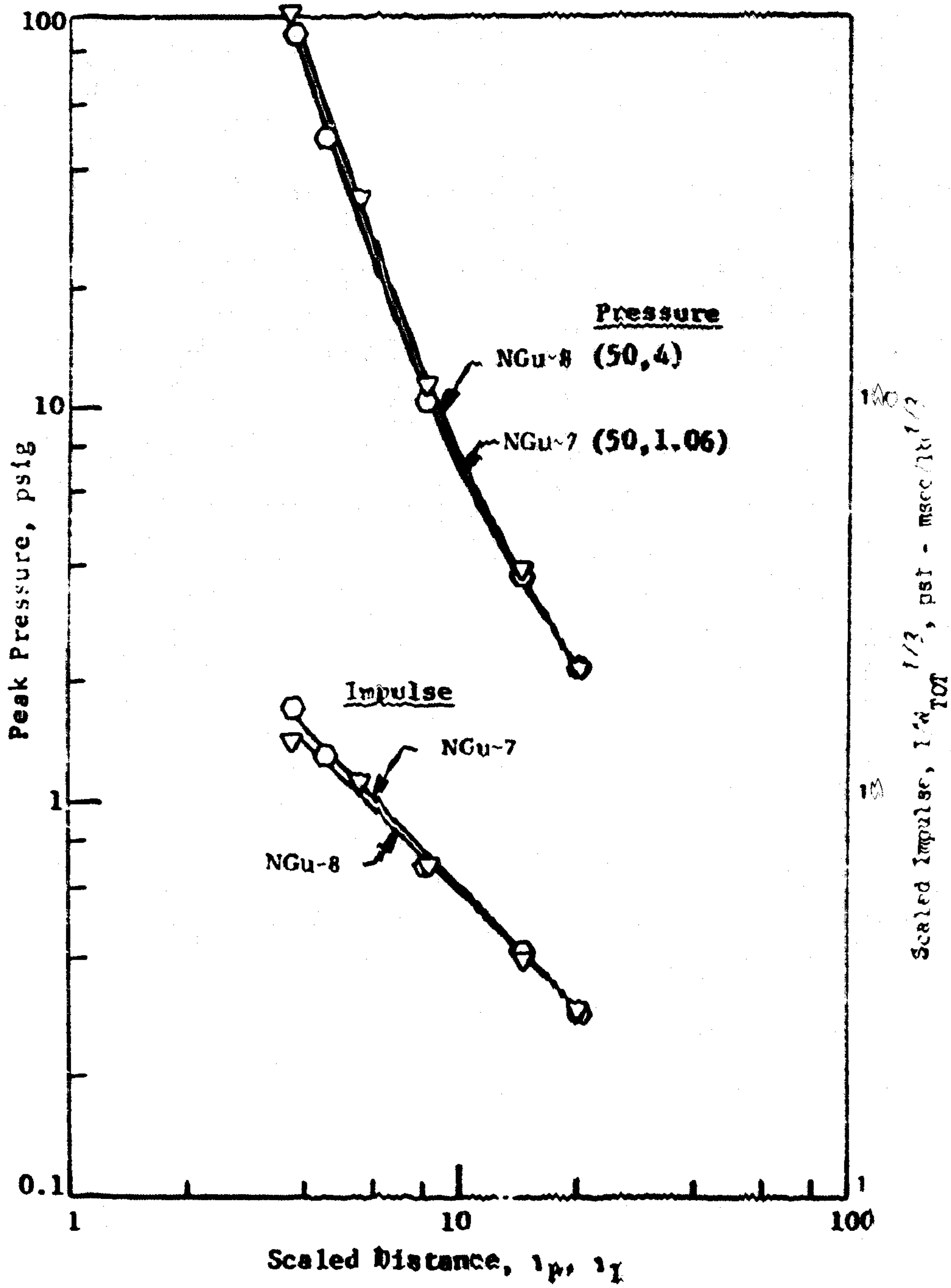

Fig 4 Effects of booster size on 50-lb NGu charge

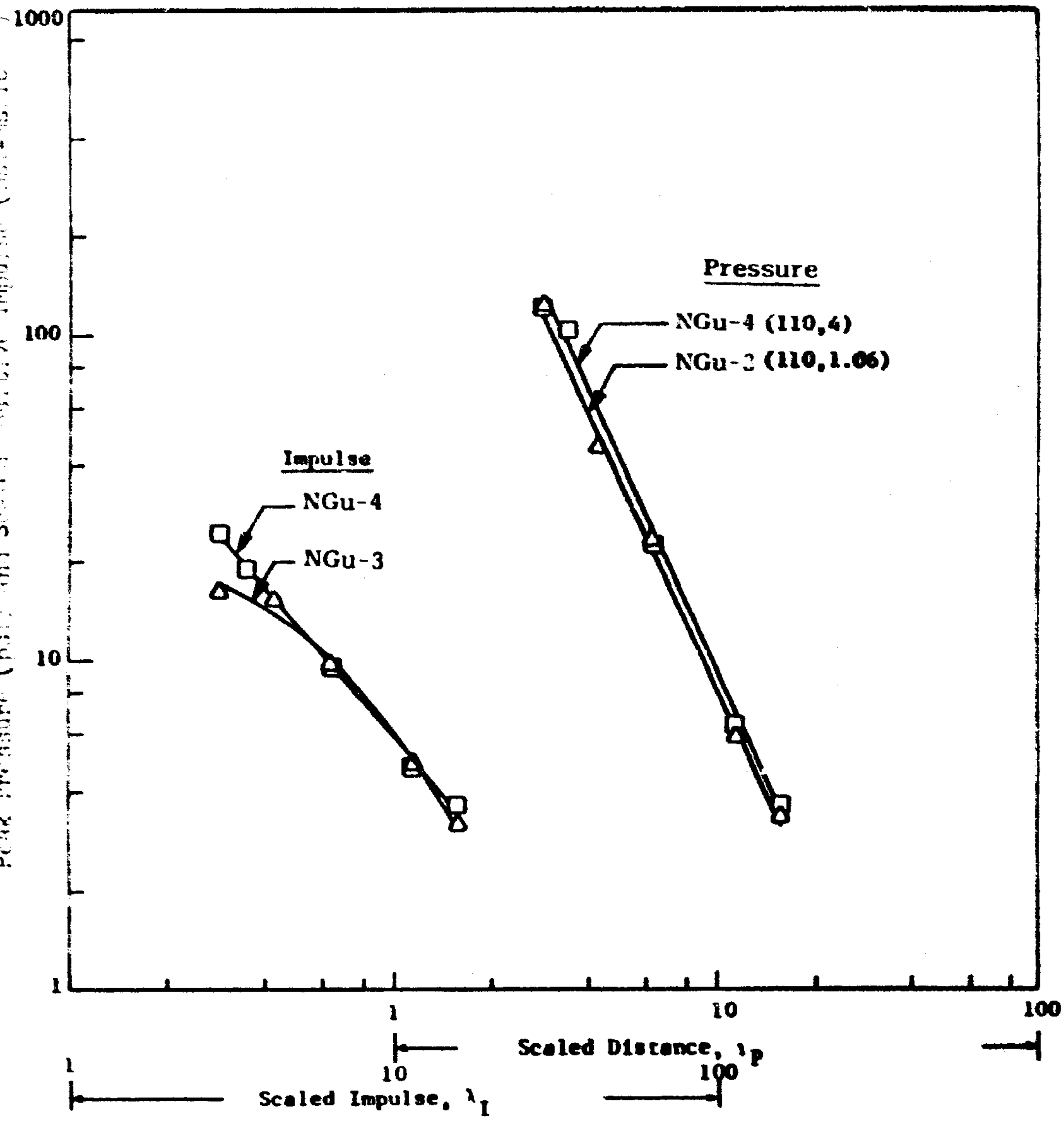

Fig 5 Effects of booster size on 110-lb NGu charge

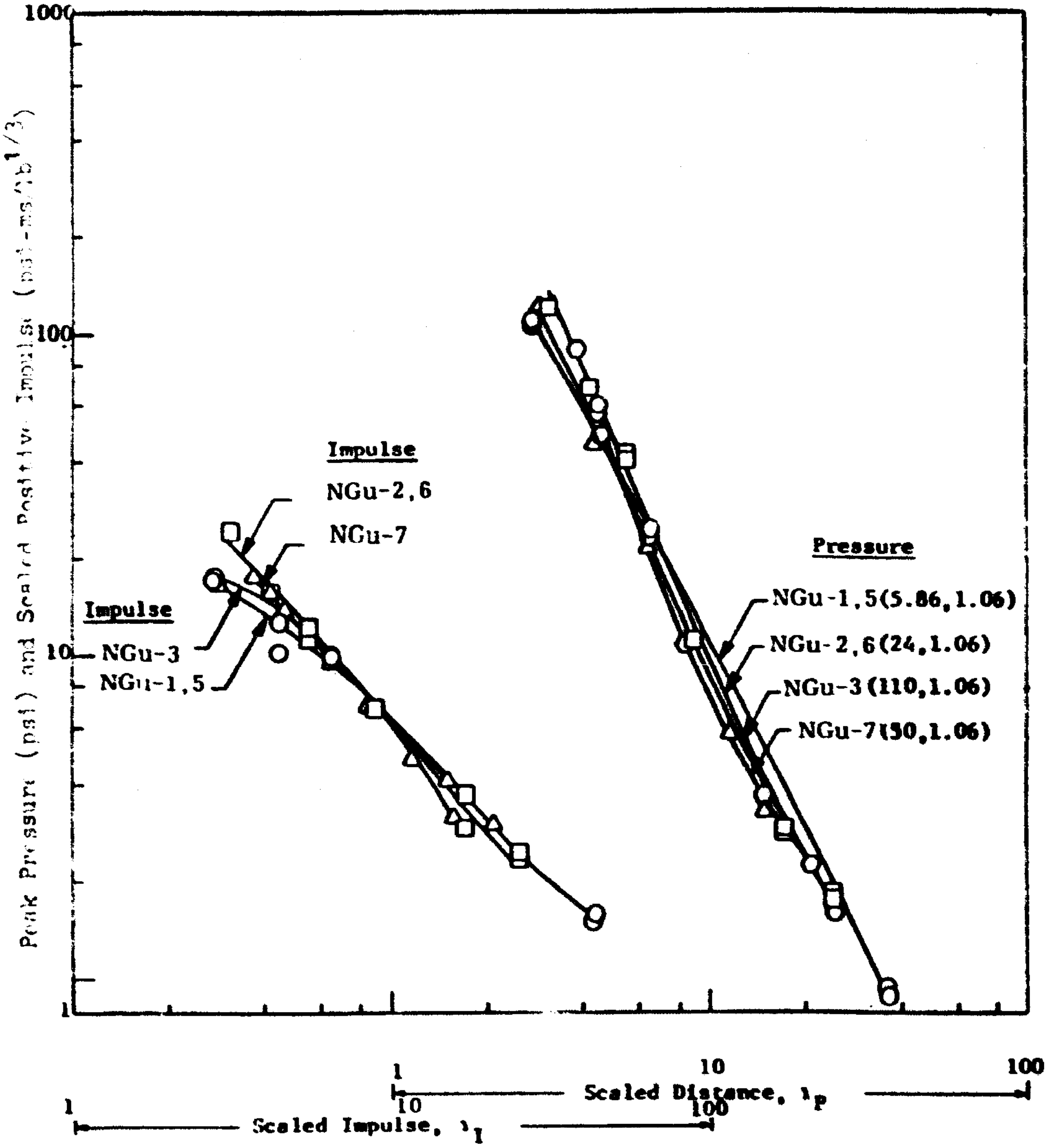

Fig 6 Effects of NGu charge weight on 1.06-oz tetryl booster

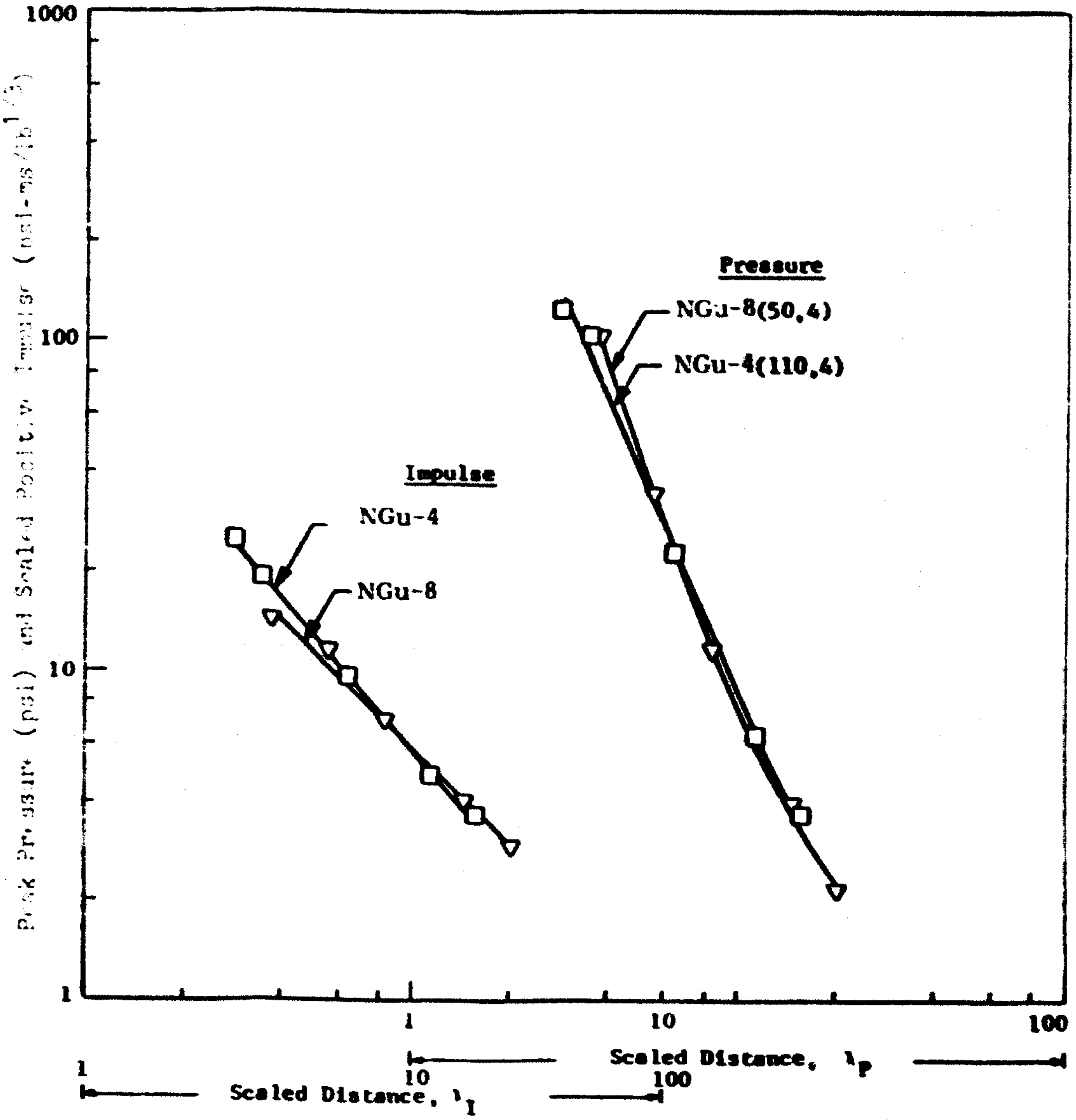

Fig 7 Effects of NGu charge weight on 4-oz Comp C4 booster

may be concluded that peak pressure and positive impulse are scalable with weight, $W^{1/3}$. Duplicate tests were averaged in these plots.

Individual data points for peak pressure and scaled positive impulse for NGu are plotted for scaled distance ft/lb$^{1/3}$ in Figure 8. Since this graph shows the relatively good agreement of the various size charges, it may be concluded that NGu is following the scaling laws (Ref 1). Figure 9 shows both peak pressure and positive impulse in terms of TNT equivalency (TNT = 100%) based on the maximum data for the scaled distances shown. Table 6 provides the maximum percent of TNT equivalencies for NGu at the scaled distances shown.

Table 6

Maximum TNT equivalencies for NGu[a]

Scaled distance (ft/lb$^{1/3}$)	Nitroguanidine (pressure, %)	(impulse, %)
3	140	110
9	105	85
18	80	90
40	70	77

[a]The material was lightly confined. Density was that of dry material 'as poured'.

Top vs Bottom Boostering

Additional tests to compare the effects of top vs bottom boostering of NGu were conducted. Two 35-lb NGu charges were initiated by 30-gm Comp C4 boosters for each situation. The results are shown graphically in Figure 10. Examination of the grouped data shows that there is no significant difference between tests with the booster on the top and those with the booster on the bottom (Ref 5). It should be mentioned that these results are in very good agreement with the data obtained from earlier tests using 50-lb NGu charges with 4-oz Comp C4 and 30-gm tetryl boosters, all bottom initiated. For NGu test No. 7, which involved a 50-lb charge boostered from the bottom, one solid line on the graph represents the pressure, the other line the impulse.

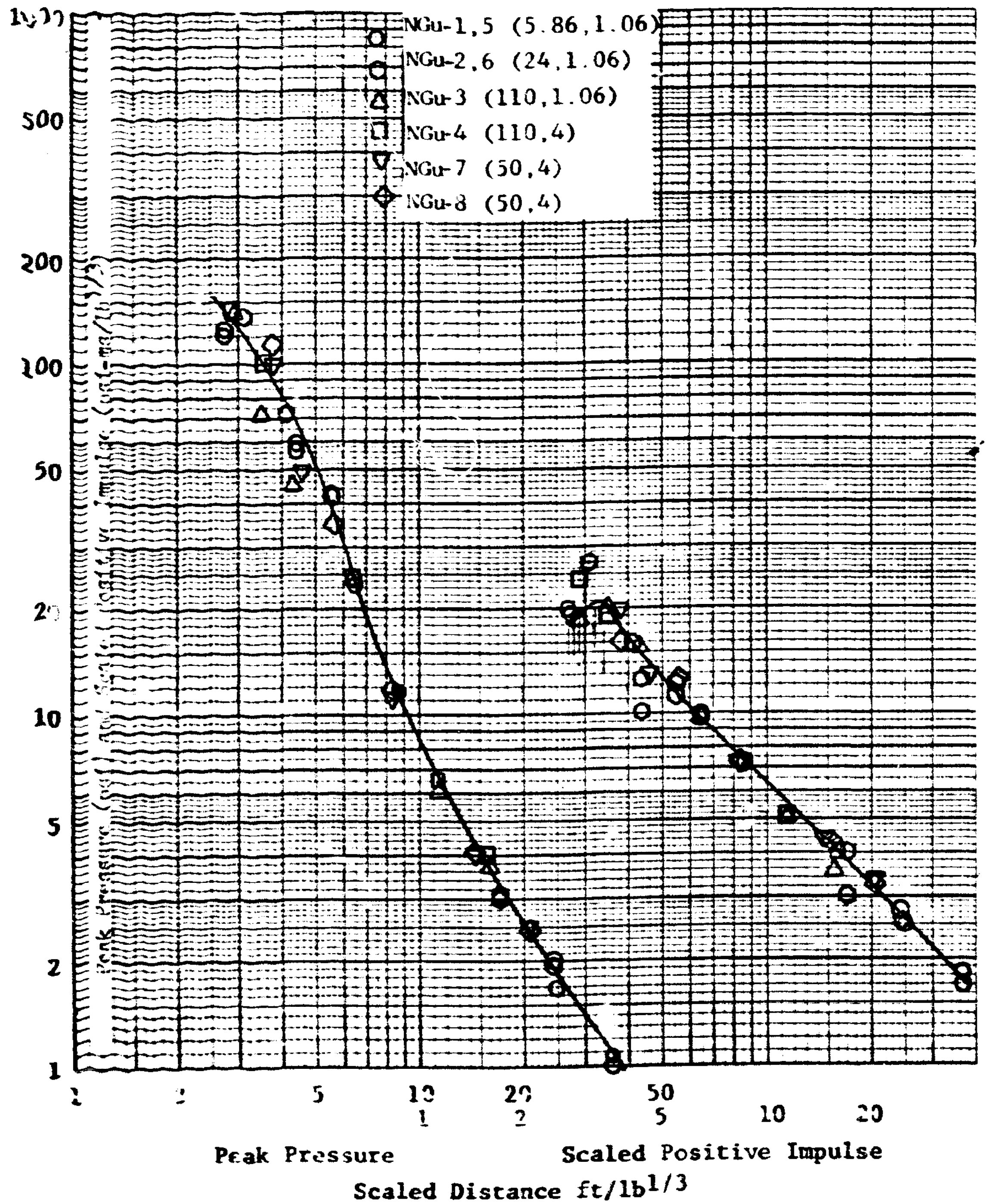

Fig 8 NGu peak pressure and scaled positive impulse

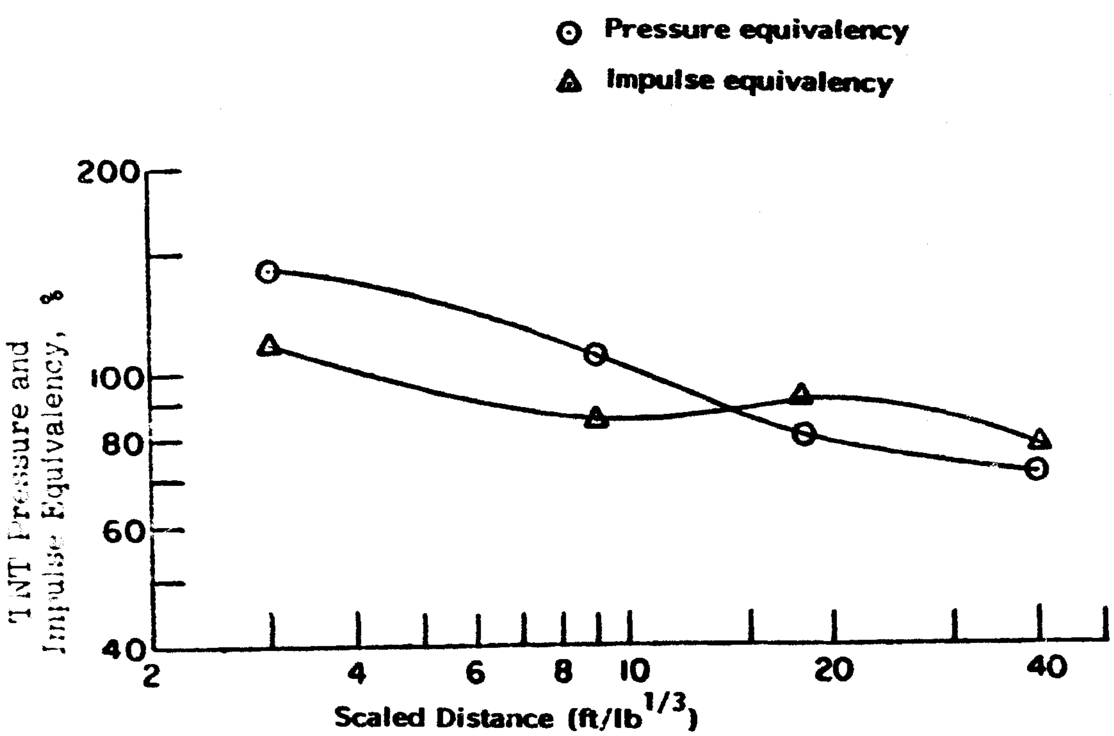

Fig 9 Maximum TNT equivalency for NGu

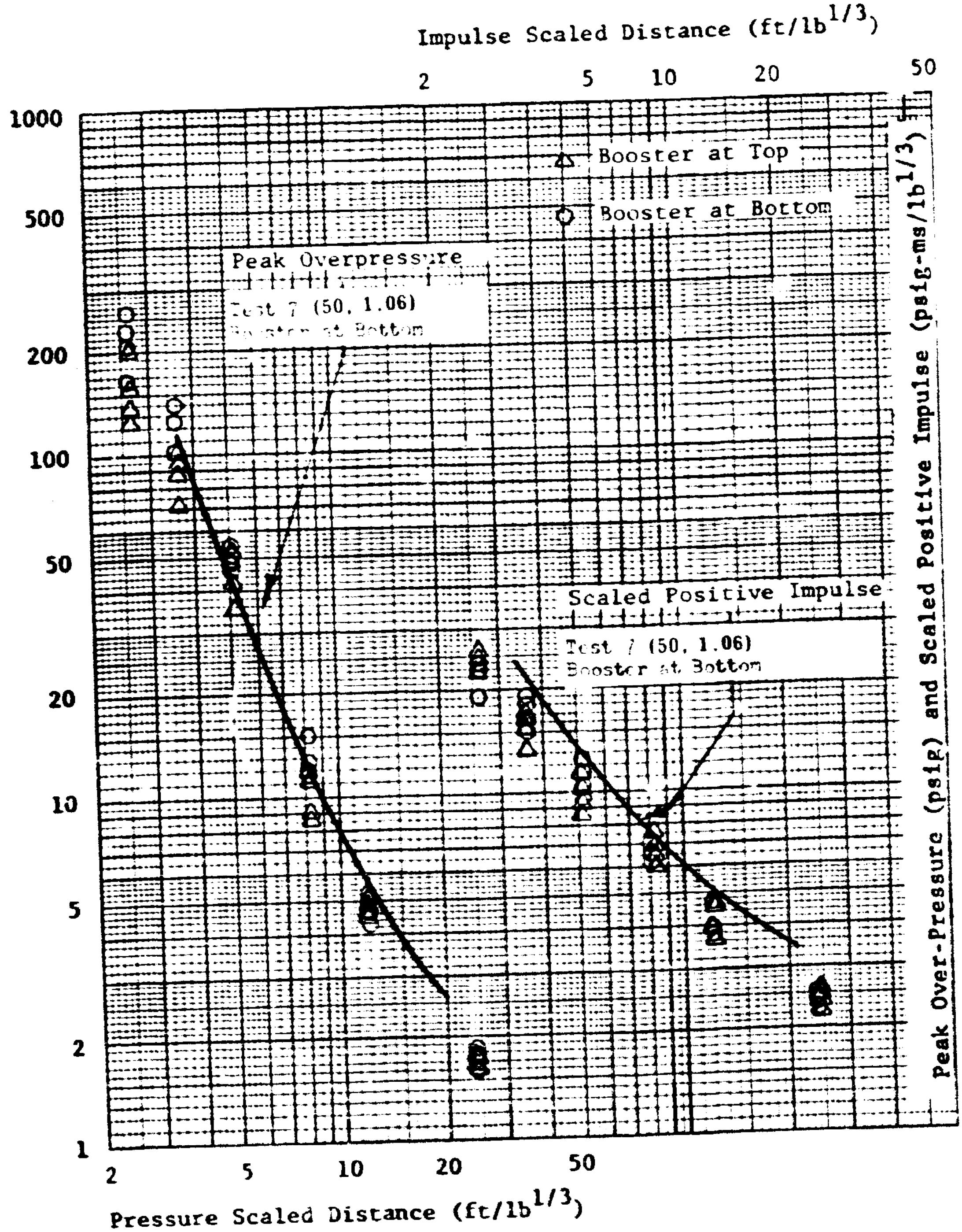

Fig 10 Effect of booster location on 35-lb NGu charge

In spite of these findings, the author does not recommend boostering loose, unconfined powders from the bottom. When GuN was boostered from the bottom, both blast pressure and fireball output were low. Considerable black residue plus unburned material were found in the test area after each firing (Ref 1). However, when the GuN was boostered from the top, thereby compressing material against the base plate and causing considerable localized friction with resulting hot spots, much larger pressure and fireball measurements were recorded (Ref 6).

Test Configurations

One of the simulated storage bins used in the NGu series of tests is illustrated in Figure 2. Aluminum walled cylinders were spot-welded together with aluminum angles, as shown. The cylinders were volume-sized by conserving the loading density of a cylindrical storage bin containing 3,000 pounds of NGu with a volume of 200 cubic feet. The length-to-diameter ratio for each cylinder was 1.0. There was a circular hole in each end plate, 1/8 as large in diameter as the cross-section of the cylinder. The thickness of the aluminum was sized by conserving the ratio of the weight of explosive to the weight of the full size bin. Table 5 lists the weight of explosive charge plus the scaling factors of the simulated storage bins used in each test in this series.

Both storage bins and calibration shots were set on a steel witness plate which was placed on the ground. Different size boosters were centered in the bottom of the bin (fig 2). Detonator leads were routed out the top of the bin. A premeasured quantity of NGu was poured into the bin through the top hole.

Test Area

The NGu test area was located in La Porte, Indiana. The test setup consisted of a concrete slab and the instrumentation shown in Figure 11. Six pressure transducers were installed flush with the top surface of the concrete slab (to measure the side-on pressure) in mechanically isolated steel plates. The test explosive was placed adjacent to one end of the concrete slab. Cables from the gages run through a covered trough in the concrete blast pad, continuing above ground to an instrumentation van (not shown in Figure 11).

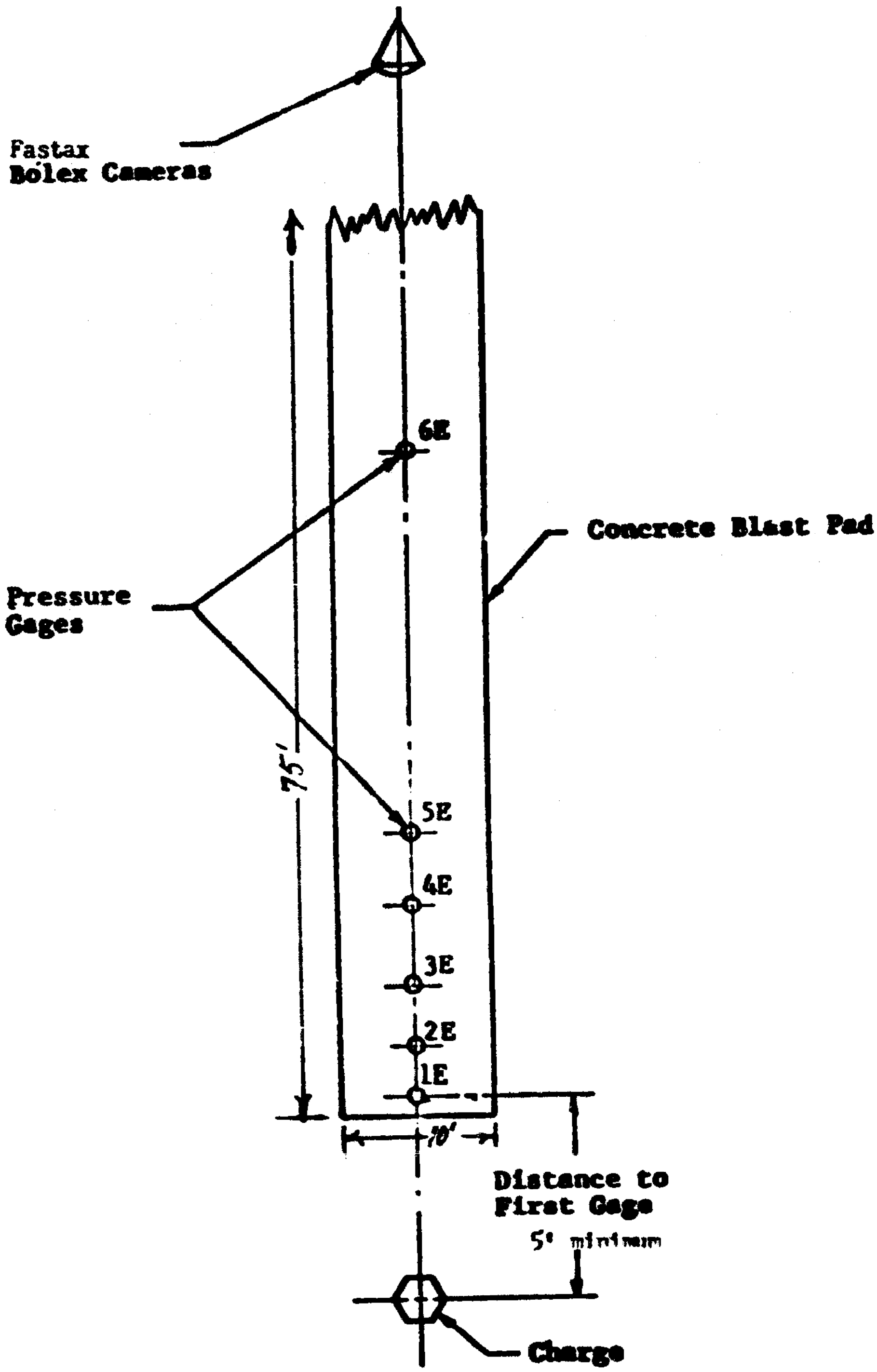

Fig 11 NGu test site plan

Calibration

Calibration tests were performed before, during, and after the regular firings of the pressure measuring system. For the NGu series, 2-lb charges were used: 5-lb charges were used during the GuN series. In both instances, the calibration charge consisted of unconfined Comp C4, hand pressed into a hemispherical shape and fired on a steel witness plate.

The resulting pressure- and impulse-gage points for the various scaled distances of the NGu series are plotted in Figure 12. The close groupings of the various sets of points provide a good basis of confidence in the proper functioning of the blast gages. The line that passes through the "peak over-pressure" gage points is a TNT pressure curve used as a standard (Ref 7). The line passing through the "scaled positive impulse" gage points was generated by the contractor for Comp C4 using a 1.25 factor to convert the weight of Comp C4 to the equivalent weight of TNT. Both of these reference curves were built into the contractor's computer program; consequently, all of the TNT equivalencies shown in this report were derived in this manner.

Guanidine Nitrate

Test Results

The peak pressure data are in good agreement for the three sizes of GuN charges tested (Fig 13). The impulse data at a scaled distance of approximately 3 ft/lb$^{1/3}$ are quite scattered (Fig 14). At this distance there appears to be no trend in the impulse data based upon charge weight. At larger scaled distances, the impulse data scale very well for the three different charge weights tested (Table 7).

Table 7

GuN test factors

Test no.	Charge weight (lb)	Booster weight Comp C4, (lb)	Bulk density (gm/cc)	Container size, (in.)
GuN-1	480	5.0	0.72	27 cube
GuN-2	480	10.0	0.72	27 cube
GuN-3	240	2.5	0.72	27 cube
GuN-4	300	8.0	0.80	32 cube
GuN-5[a]	145	1.0	----	20 x 20 cyl

[a]From earlier test (Ref 1).

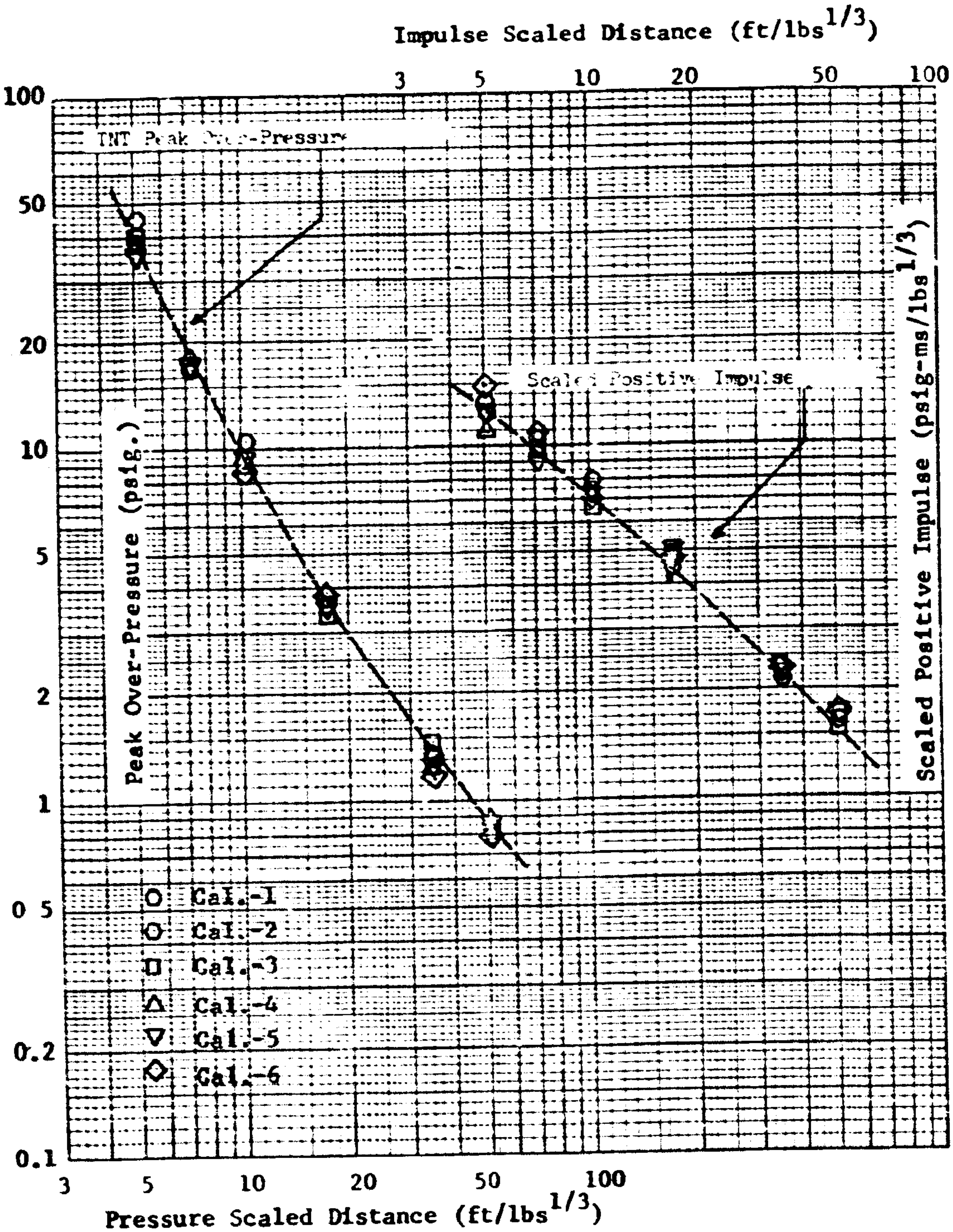

Fig 12 Calibration test data for NGu

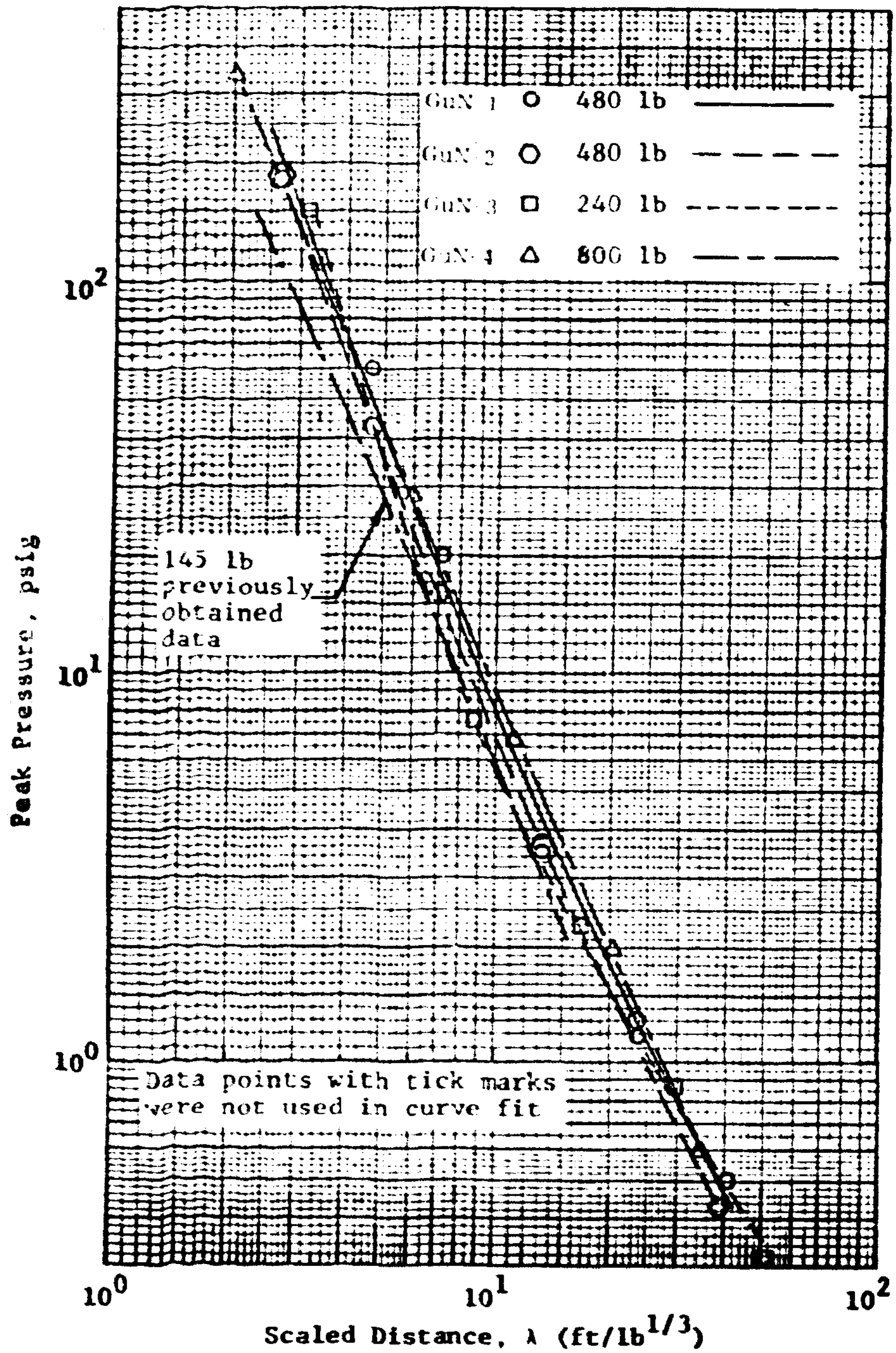

Fig 13 GuN peak pressure

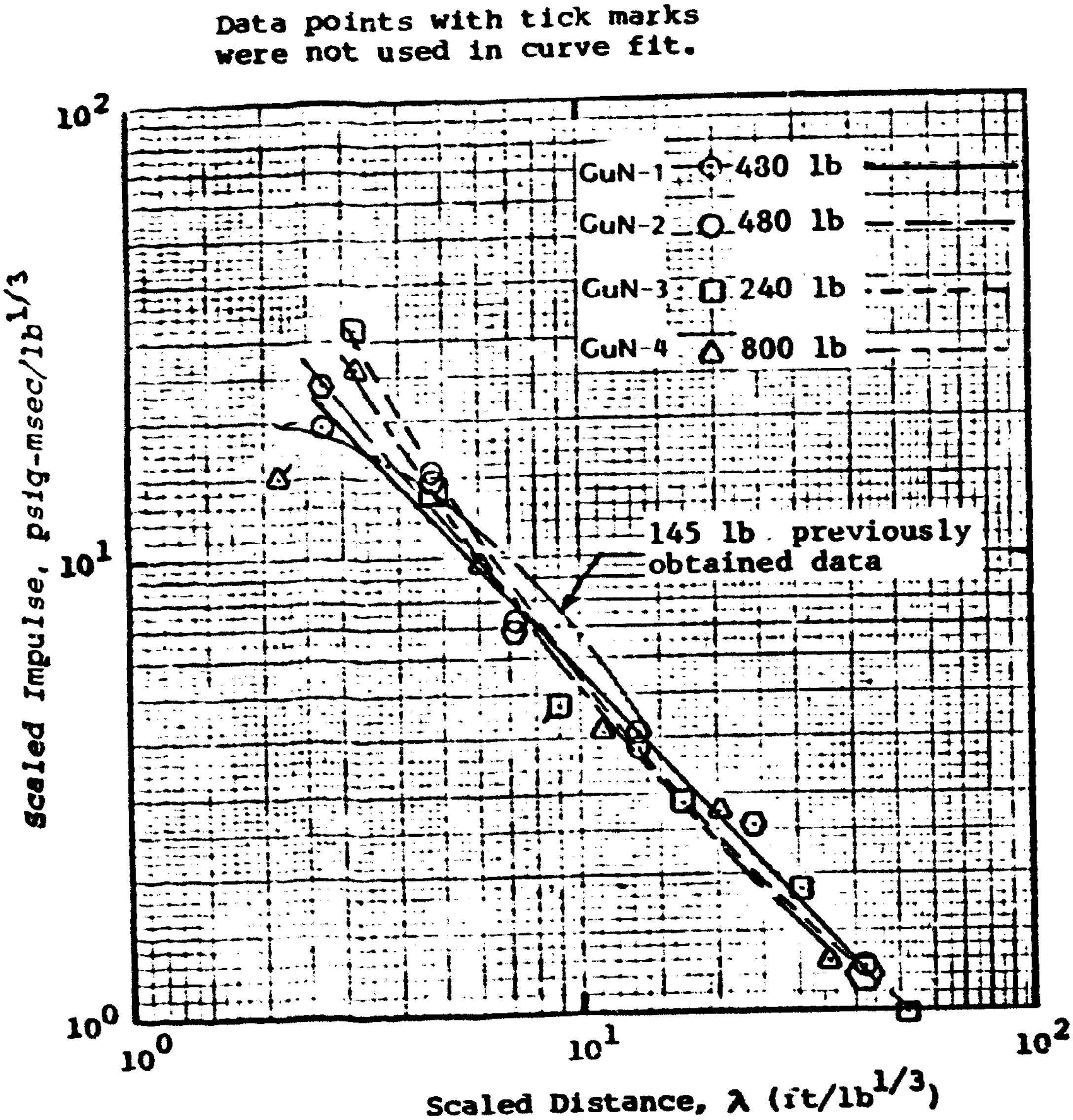

Fig 14 GuN scaled impulse

Data from a 145-lb charge, using a 1-lb Comp C4 booster embedded in the bottom, are also included in Figures 13 and 14. The scaled pressure output from this charge is lower than that of the larger charges which were boostered from the top. However, the scaled impulse measured from the 145-lb test is approximately the same as that measured during the larger weight tests. It is noted that some of the GuN did not ignite during the 145-lb test, which probably accounts for the low peak pressure.

Both average pressure and average impulse versus scaled distance curves were drawn for all charges using top boostering. This was done by curve fitting all of the peak pressure-scaled distance and scaled impulse-scaled distance data, respectively, for the charges weighing 240 pounds or more. Figure 15 illustrates the results of averaging these curve fits and compares them with the corresponding blast parameters from a standard hemispherical TNT charge (Ref 7). At small scaled distances there is more blast output from guanidine nitrate than there is from TNT (Ref 6).

The TNT equivalence of guanidine nitrate was computed using the averaged curves f r peak pressure and scaled impulse. The TNT equivalence is plotted in Figure 15.

The maximum TNT equivalency data for both pressure and impulse for scaled distances ranging from 3 to 40 ft/lb$^{1/3}$ is given in Table 8 and shown graphically in Figure 15.

Table 8

Maximum TNT equivalencies for GuN[a]

Scaled distance (ft/lb$^{1/3}$)	Guanidine nitrate (pressure, %)	Guanidine nitrate (impulse, %)
3	140	250
9	100	67
18	50	62
40	16	56

[a]The material was lightly confined. Density was that of dry material 'as poured'.

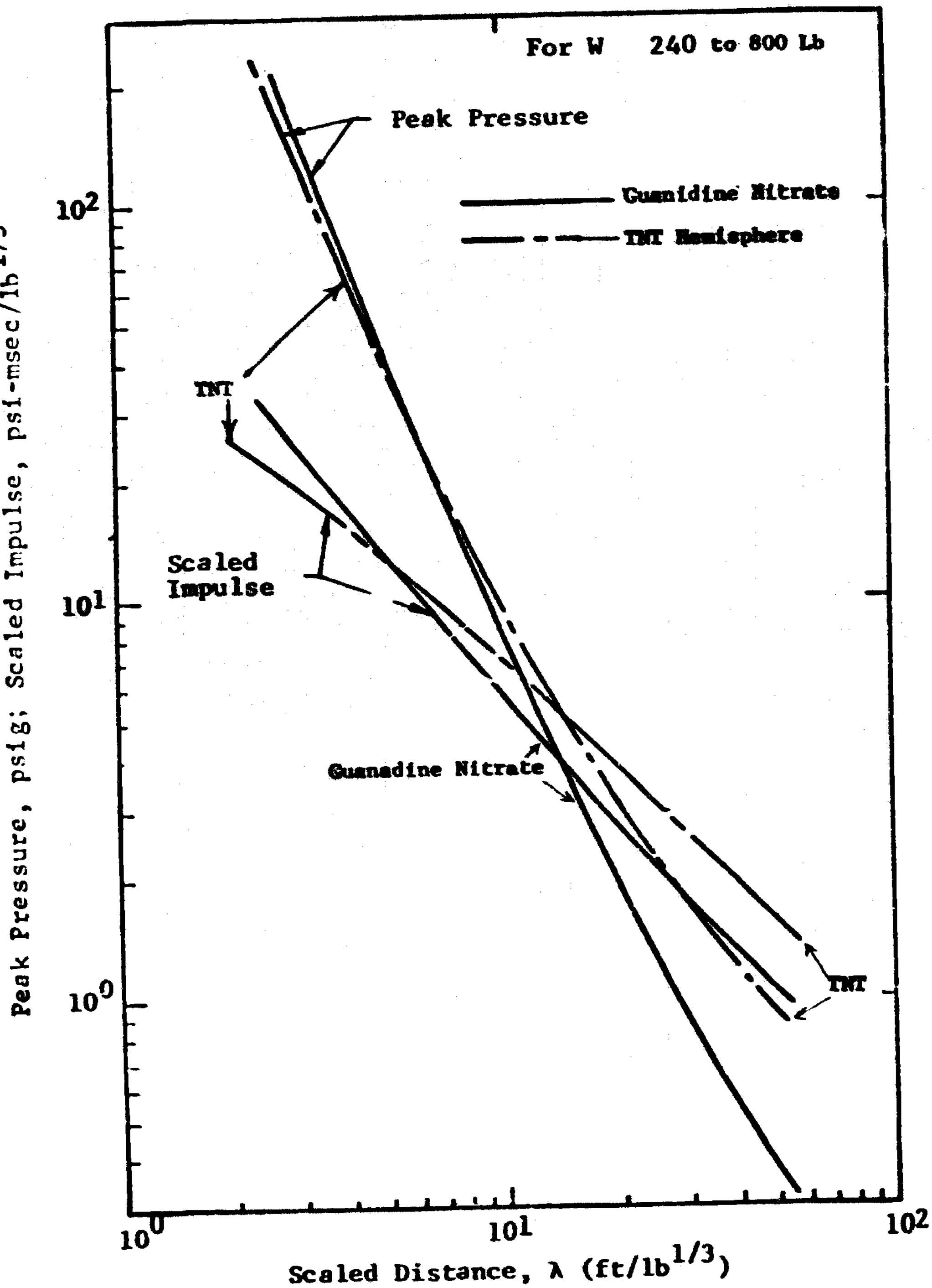

Fig 15 Peak pressure and scaled impulse--comparison of GuN and TNT

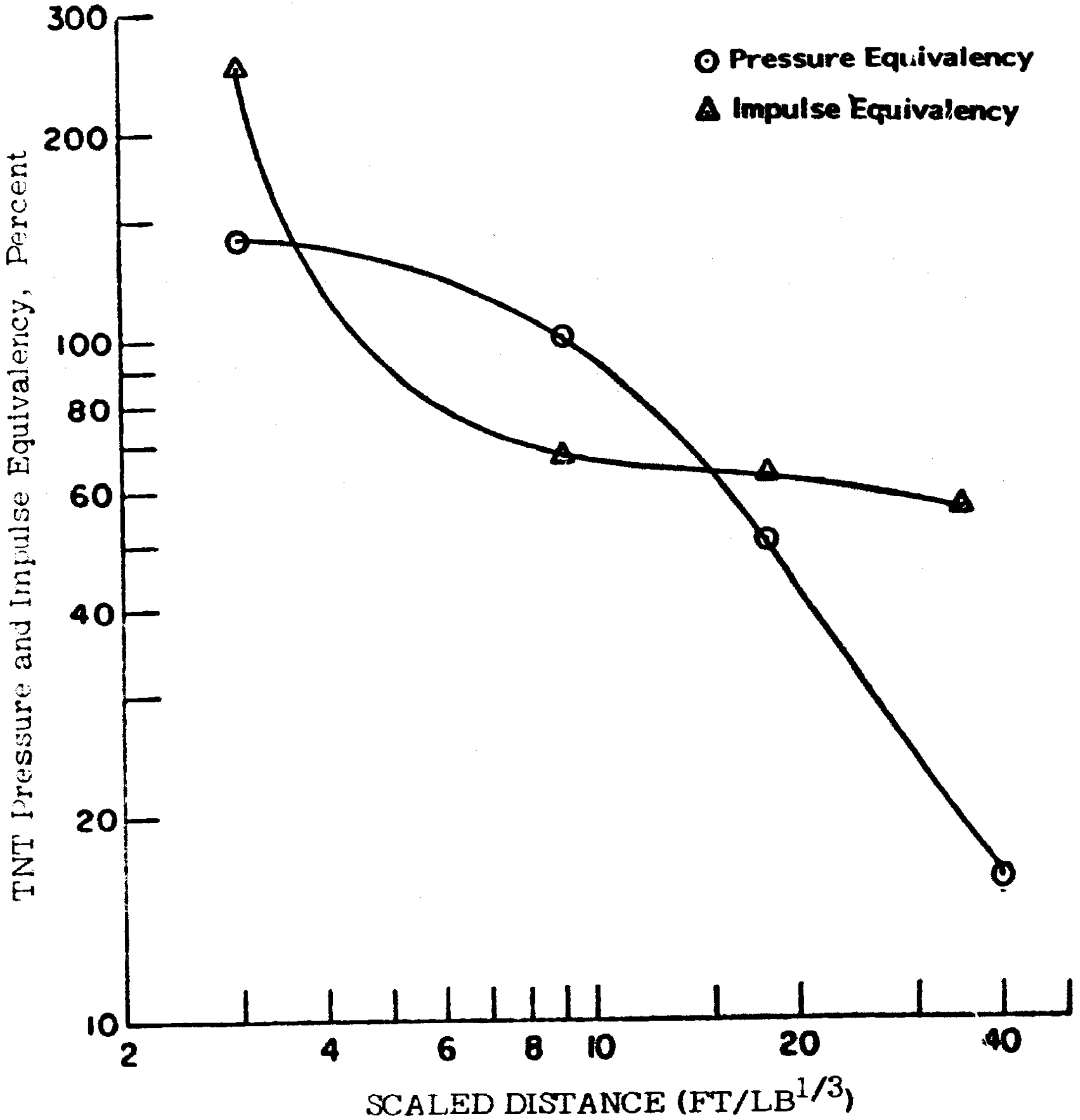

Fig 16 Maximum TNT equivalency for GuN

Fireball Size

Fireball radius versus charge weight data, Table 9, is plotted in Figure 7. The solid line represents the fireball radius obtained from several exploding liquid propellant charges. (The liquid propellants used to obtain these data were LOX/RP-1, LOW/LH_2, LOX/RP-1/LH_2, and N_2O_4/N_2H_4/UDMH, Reference 8.) The dashed curve to the left in the figure was obtained from some previous work (Ref 1), in which several 18.5-lb and one 145-lb GuN charges were incompletely ignited from the bottom. These charges produced smaller scaled fireballs, probably due to poor ignition, since some of the GuN remained after these tests. The fireballs produced during the larger or current test series (dashed line to the right) were more nearly the same size as those produced by propellants (Ref 6). In these latter tests, the booster was embedded in the top center of the charge.

Test Configuration

A typical test configuration for the GuN series is illustrated in Figure 18. Cubical boxes were constructed from 0.25-in.-thick plywood sheets. Wood 2 by 4's were used at the edges of the boxes, and a few metal bands were placed around each box for support. The boxes were used to support and shape the GuN charges, affording minimal confinement. GuN was loosely poured into the boxes, and large lumps were broken up, but no attempt was made to grind or compact the material.

Table 9

GuN fireball data[a]

Test no.	Booster size (lb)	Charge weight (lb)	Fireball diameter (ft)
GuN-1	5.0	480	65
GuN-2	10.0	480	65
GuN-3	2.5	240	55
GuN-4	8.0	800	70

[a]Data from IIT Research Institute (Ref 6).

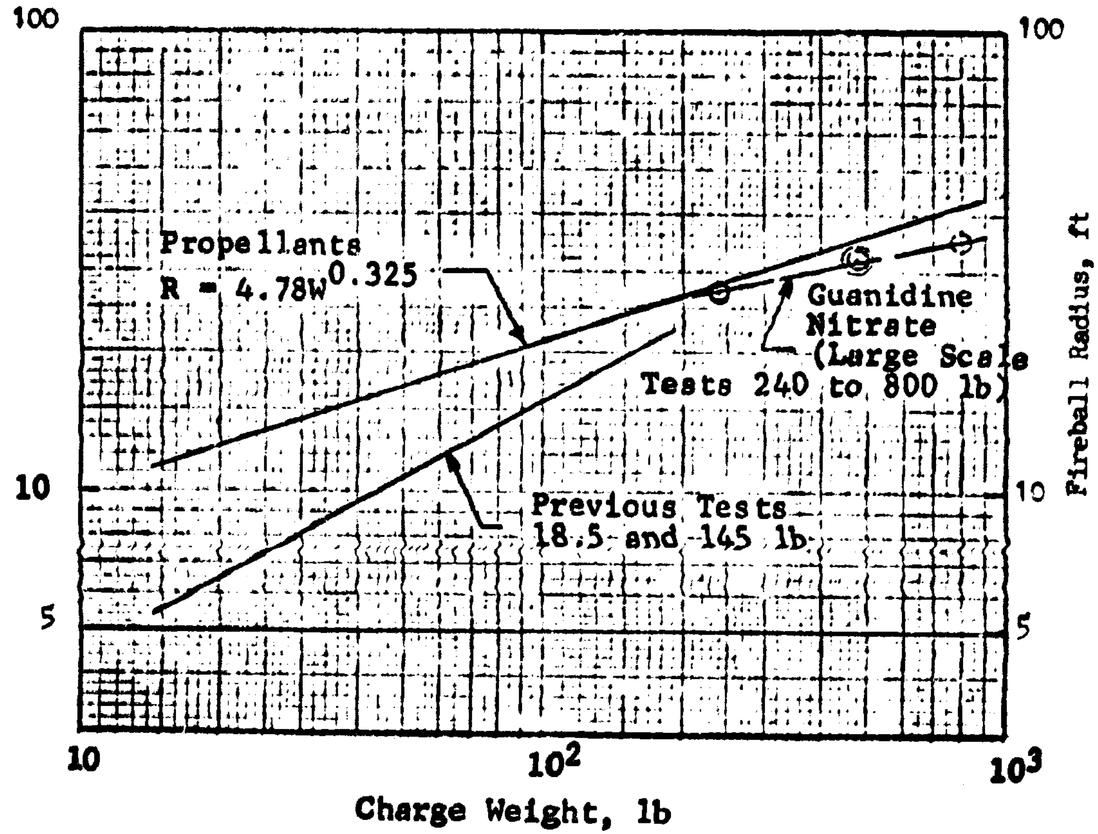

Fig 17 Fireball radius

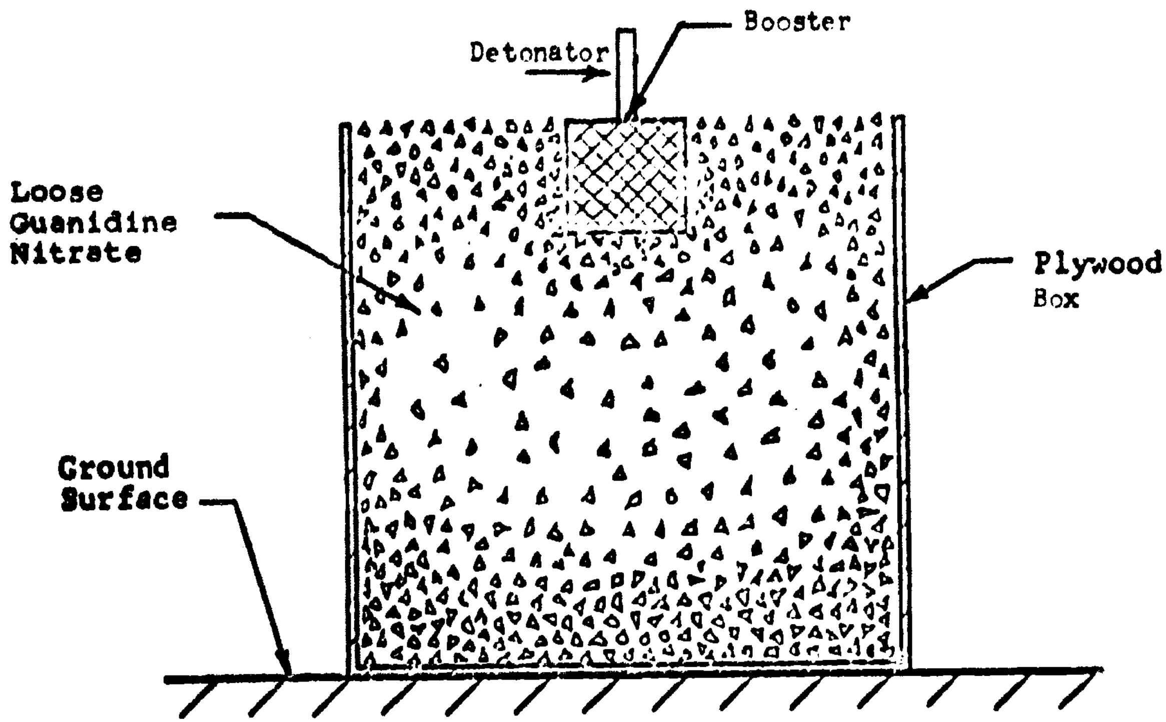

Fig 18 Loosely packed GuN in test configuration

Each GuN charge was ignited with a Comp C4 booster. The boosters were shaped into rough cubes and, in this series, embedded near the top surface of the charge (Fig 18). Two U. S. Army special electric blasting caps, wired in parallel, were used to ignite the boosters.

Test Area

The GuN tests were performed at Dugway Proving Ground, Dugway, Utah, a desert test site free from surface obstructions.

Two motion picture cameras were used to record each test event. They operated at approximately 4,000 frames per second and were located as shown in Figure 19. Eight fiducial markers were located in each camera's field of view. The fiducial marks were used to determine maximum fireball size. The high speed cameras were time sequenced with the shot firing circuit.

Pressure gages were flush mounted in 20-in.-square by 1-in.-thick steel plates which were, in turn, flush mounted in the ground and secured with stakes. They were located at discrete intervals on a radial line from ground zero (GZ). Cables from the gages were buried in the immediate area of the charge and laid above ground for the remaining distance to the instrumentation trailer. The gage positions ranged from 20 to 333 feet from GZ. Nine gages were positioned in the field to provide greater pressure range flexibility from test to test, though only six were used during any one test (Ref 6).

Detailed information concerning pressure measuring, recording, reproduction and calibration instrumentation, and procedures is contained in Appendix B of the IIT Research Institute's final report on the program (Ref 1).

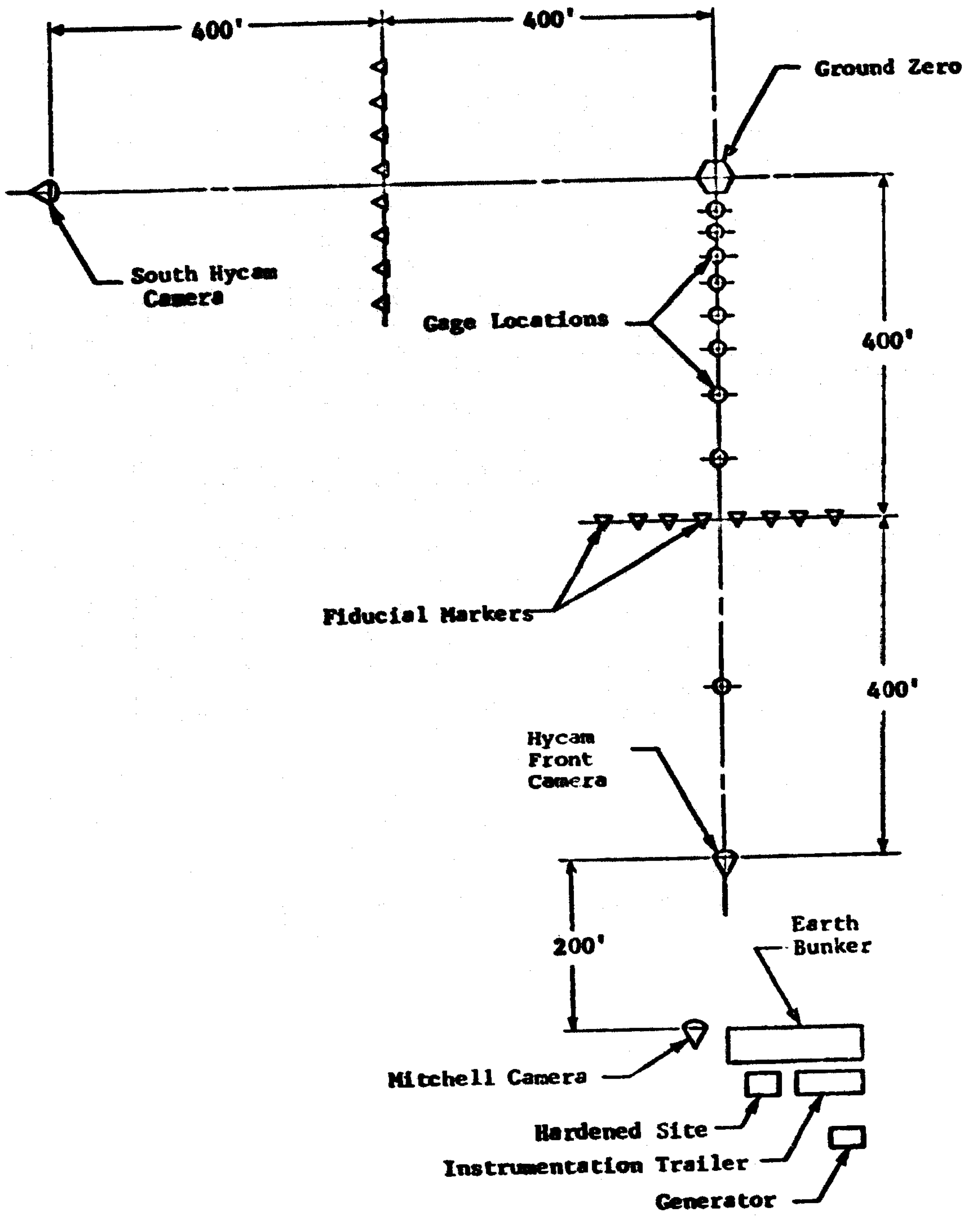

Fig 19 GuN test site plan

CONCLUSIONS

Nitroguanidine

1. Is less sensitive to shock initiation than TNT and most other explosive materials studied except for guanidine nitrate.

2. Once detonated, can produce a significantly higher peak pressure at close-in distances than that of an equivalent weight of TNT.

3. Appears to follow the scaling laws for explosives within the parameters tested; consequently, the data contained in this report can be extrapolated to full size charges.

Guanidine Nitrate

1. Is more difficult to shock initiate than nitroguanidine.

2. When ignited, has a low rate of detonation.

3. Once ignited, can produce a peak pressure and positive impulse significantly greater than that of an equivalent weight of TNT at close-in distances.

4. Appears to follow the scaling laws for explosives within the parameters studied; consequently, the data contained in this report can be extrapolated to full size charges.

REFERENCES

1. H. Napadensky and J. Swatosh, *TNT Equivalency of Nitroguanidine and Guanidine Nitrate*, IITRI Final Report J6276-1, IIT Research Institute, Chicago, Illinois, May 1973

2. Basil T. Fedoroff and Oliver E. Sheffield, *Encyclopedia of Explosives and Related Items*, Picatinny Arsenal Technical Report 2700, Vol 6, 1974

3. Donna Price and A. R. Clairmont, Jr., *The Response of Nitroguanidine to a Strong Shock*, NOL Technical Report G7-169, U. S. Naval Ordnance Laboratory, White Oak, Maryland, February 1968

4. R. E. Van Syckel, *Erosion Test of Ballistically Matched Picrite (Nitroguanidine) and Non-Picrite Propellants,* Ballistic Research Laboratories Report 1083, Aberdeen Proving Ground, Maryland, October 1959

5. Daniel Spandoni, IITRI, to Shepherd Levmore, Picatinny, private communication, April 28, 1975

6. James J. Swatosh, Jr., *TNT Equivalency of Large Charges of Guanidine Nitrate,* IITRI J6276-3, Engineering Mechanics Division, IIT Research Institute, Chicago, Illinois, September 1974

7. C. N. Kingery, *Air Blast Parameters Versus Distance for Hemispherical TNT Charges,* Ballistic Research Laboratories Report 1344, Aberdeen Proving Ground, Maryland, September 1966

8. *Hazards of Chemical Rockets and Propellants Handbook,* Chemical Propulsion Information Agency, CPIA/194, AD 889763, The Johns Hopkins University, Applied Physics Laboratory, Silver Spring, Maryland, May 1972

APPENDIX

Approval of Preliminary Report on the TNT Equivalencies of Nitroguanidine and Guanidine Nitrate

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Mr. Skogman/ksp/69[illegible]9

AMSAR-SFD (26 Mar 75) 1st Ind
SUBJECT: Preliminary Report on the TNT Equivalencies of Nitroguanadine and Guanadine Nitrate

HQ, US Army Armament Command, Rock Island, IL 61201 17 APR 1975

TO: Commander, US Army Materiel Command, ATTN: AMCSF-E

This office has reviewed the subject report. It is recommended that a TNT equivalency of 100% be approved for use at barricaded intraline distance (Z=9) and beyond. It is further recommended that the higher TNT equivalencies determined at close-in scaled distance be approved for use.

FOR THE COMMANDER:

SIGNED

1 Incl
cy 12 wd

STEPHEN K. CHURTHWAITE
Safety Engineer

AMCSF-E (26 Mar 75) 2nd Ind
SUBJECT: Preliminary Report on the TNT Equivalencies of Nitroguanadine and Guanadine Nitrate

HQ, US Army Materiel Command, 5001 Eisenhower Ave., Alexandria, VA 22333
22 April 1975

TO: Commander, US Army Armament Command, ATTN: AMSAR-SFD, Rock Island, IL 61201

Based on the information submitted, the recommendations contained in the 1st indorsement, regarding the application of subject TNT equivalencies, are considered satisfactory from an explosives safety viewpoint.

FOR THE COMMANDER:

1 Incl
wd 8 cys

Walter G. Queen
WALTER G. QUEEN
Chief
Safety Office

Cy Furn (w/incl):
DDESB
FSA (AMXOS-ES)
HQDA (DAIG-SD)
DSA (DCAS-QS)
IGD (AFISC/SEV)
NAVSEASYSCOM (SEA-04H)

DEPARTMENT OF DEFENSE EXPLOSIVES SAFETY BOARD
WASHINGTON, D.C. 20314

DDESB-KT

14 May 1975

SUBJECT: Preliminary Report on the TNT Equivalency of Nitroguanidine and Guanidine Nitrate

Commander
US Army Materiel Command
ATTN: AMCSF-E
5001 Eisenhower Avenue
Alexandria, VA 22333

1. Reference:

a. Picatinny Arsenal. Preliminary Report of 26 March 1975, "The TNT Equivalency of Nitroguanidine and Guanidine Nitrate."

b. AMC 2nd Indorsement AMCSF-E (26 Mar 75) of 22 Apr 1975 to Picatinny Arsenal letter SARPA-MT-F of 26 March 1975, same subject.

2. A copy of reference 1a was forwarded to this office by reference 1b. Based upon the technical content of reference 1a, as well as the approval by the Army Materiel Command of the TNT equivalency of the subject materials, it is suggested that reference 1a be placed in the Defense Documentation Center (DDC). Should it be determined that reference 1a is too preliminary in nature, it is recommended that the final report be placed in DDC. Information of this nature should be readily available to all interested parties.

P F Klein

P. F. KLEIN
Captain, USN
Chairman